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Title of Proposed Observation:

Coronal loop magnetic field determination and evolution through coronal rain tracing - co-observation between SST, Hinode, IRIS and Meudon.

Main Objective:

The aim of this project is to infer the full magnetic field vector along coronal loops through coronal rain observation.

Scientific Justification:

Coronal rain is the direct observational signature of the thermal instability mechanism in the solar corona. It corresponds to cool and dense (spanning chromospheric to transition region conditions) partially ionised clumpy plasma falling along coronal loops. Recent studies show that this phenomenon has a ubiquitous presence above active regions (Antolin & Rouppe van der Voort 2012, Antolin et al. 2015).

One of the unique features of tracing coronal rain is that it is currently the highest resolution method to trace out the coronal magnetic field vector. By tracking the clumps both global and local reconstruction of the coronal magnetic field topology can be achieved. The aim of this project is to take one step further in this direction and use the coronal rain properties to infer the full magnetic field vector along the coronal loops. To achieve this goal we aim at co-observing in various magnetically sensitive lines:

- At the SST (for which the observers will be N. Freij and P. Antolin): we will conduct full polarimetric observations in the Ca II 8542 line, combined with H-alpha spectrometric observations of the rain. Coronal rain is commonly observed in H-alpha, and has also been previously observed in the Ca line with FISS at the NST (Ahn et al., 2014), with TIP-II at the VTT (Collados et al., 2014) and also with the SST (Scullion et al. 2016, in prep.). Previous spectropolarimetric observations in which coronal rain is present can also be found in Schad (2013).

- With Hinode/SOT (SP+BFI) we aim at observe coronal rain and measure at high resolution the magnetic field strength at the photospheric footpoints of the loops. This will allow in turn to perform magnetic field extrapolations. Comparison between these extrapolations and the coronal rain paths will serve as a test for the extrapolation methods and also as a means to estimate the non-potentiality of the active region.

- With IRIS and Hinode/EIS we aim at studying the change in the thermodynamic evolution of the rain, as it cools through the transition region down to chromospheric temperatures, and also to perform coronal MHD seismology. Indeed, since transverse MHD waves are commonly observed in rainy loops (Antolin & Verwichte 2011), we also aim at observing these waves at high resolution, especially at the apex of the loops. Having the slit crossing the loops close to the apex is essential, since it allows to detect the presence of resonant absorption and dynamic instabilities (Okamoto et al. 2015, Antolin et al. 2015b). The detection of transverse MHD waves will allow to perform coronal seismology, which will therefore serve as an additional and independent measurement of the coronal magnetic field.

- With Meudon/MSDP continuous H-alpha spectrometric observations will be performed over a larger field-of-view, thereby complementing the SST observations above.

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SSC Point of Contact: Yukio Katsukawa (NAOJ)

Dates:

Same as SST co-observing dates for this project:
April 4 - 17, 2016
May 30 - June 10, 2016
Follow-up of active region during several consecutive days is desired

Time window:

The best observing time at SST is in the morning from UT 07:30 - 12, followed by the afternoon from UT 15 – 17. Please aim at co-observing at these times for at least one uninterrupted hour if possible.

Target(s) of interest:

- Off-limb, above active region (keep always at least 20” of on-disc region for co-alignment purposes).
East or West pointing
- On-disk active region

SOT Requests:

SP & BFI with priority on SP:

- SOT/SP: ~ 170 Mbits
SP IQUV fast map scan of 123’’ x 123" FOV (~25 min) during the entire run. For one hour observing run SP is therefore expected to run 2 times.
If the target is too close to limb then it is ok not to run SP if it is not considered appropriate by the SOT team. However, it is good to point out that even in this case a signal from coronal rain may be obtained from off-limb structures, as has been obtained for HMI observations (Martínez-Oliveros 2014). A search for this signature could help establish the physical process behind this HMI emission.

If BFI is working then:
Program number 04cd
- Ca II H at a cadence around 10 sec with exposure times long (1.8s)
- Half CCD for higher cadence
- No 2x2 summing (we need high spatial resolution)
Note: if 1 hour results too heavy for telemetry then please perform 2x2 summing.

EIS Requests:

EIS study 434 (VHH_SlowAR_SaS_1h6m), which does a sit and stare, 30 s exposure time, with the 2” arcsec slit with a slit length of 296 arcsec. Slit should be perpendicular to limb. If possible, make the slit cross at centre of coronal loops (thus aiming for the apexes). Context 40 arcsec slot before / after the sit-and-stare.

XRT Requests:

None

IRIS Requests:

1. Observation modes: Sit-and-stare & raster

2. For sit-and-stare mode: Very Large (or Large) sit-and-stare. The slit needs to cross the loops at the apex, meaning generally perpendicular to limb or at 45 degrees depending on loop orientation.
For raster: Very Large (or Large) dense 320-step raster 105.3x120. roll-angle of 0 degrees is ok in this case (slit parallel to limb).

3. Medium line list. For the SJI, do 2796, 1400 and 2832 (lower cadence) (“Si IV Mg II h/k Mg II w s”).

4. Duration: The sets should be at least 1 hour long. Alternate between sit-and-stare and raster.

5. Sum FUV spectrally by 2.

6. Exposure time for the slit should be 8s, for a cadence of ~9s. For SJI roughly same cadence.

7. If problems of telemetry are encountered then set the slit to 120" instead of 175".

Tentative OBSIDs:
sit-and-stare: 3620258404, 3620258403
raster: 3620258477, 3620258476

Additional instrument coordination:

SST, Meudon

Previous HOP information:

IHOP 248 & 262
Reeves K. et al. 2015
Baba et al. in prep.
Antolin P. et al. (2015, ApJ 806)
Antolin P. et al. (2016, in prep.)
Pant V. et al. (2016, in prep.)

Additional Remarks:

Details for other co-observing instruments:

SST:
Time has been already allocated for this project (PI: R. Oliver) in the dates specified above. The observations will consist of H-alpha + Ca II 8542 and Fe I 6302 full Stokes at both on-disc active regions and (near) off-limb.

Meudon:
H-alpha spectrometric coverage (larger FOV) of the active region.